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(54) HID lamp having an arc tube with offset press seals.

(57) A high pressure discharge lamp having an arc tube (3) for operation in a generally horizontal position. The arc tube (3) has a generally cylindrical body with end chambers (16) of reducing cross-section in which respective discharge electrodes (15) are arranged. Press seals sealing the end of the arc tube (3) in a gas tight-manner are offset from the axis of the cylindrical body in a direction normal to the press seals.

The lamp has an improved performance and the standard deviation of lamp parameters is smaller.

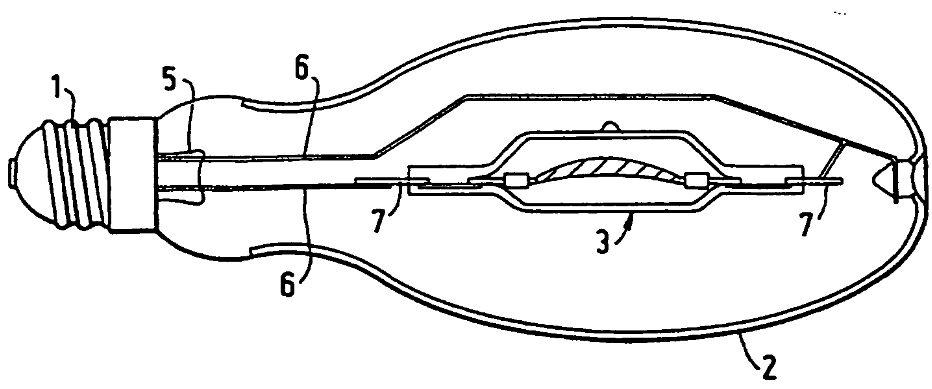

FIG.3

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The invention relates to a high pressure discharge lamp having an arc tube for operation in a generally horizontal position, said arc tube having a generally cylindrical body defining a cylinder axis, end chambers of reducing cross-section, an arc discharge sustaining filling, a pair of opposing discharge electrodes arranged substantially in said end chambers, and press seals each having opposing major faces, sealing each end of said arc tube in a gas-tight manner.

Lamps of this type are known from U.S. Patent 4,001,623 which discloses a metal halide lamp. In such a lamp, the arc tube is made of quartz glass to withstand the high operating temperature of the arc discharge. The discharge sustaining filling is typically comprised of mercury and a starting gas, along with one or more metal halides such as sodium halide and scandium halide to improve the color of the lamp.

When a metal halide arc tube is operated horizontally, the arc bows upward due to convection currents within the discharge space. This tends to overheat the upper wall of the are tube, which leads to a shortened lamp life. The bowed arc also causes an uneven temperature profile between the upper and lower walls of the arc tube, leading to increased condensation of the filling as compared to a similar vertically operated lamp. This adversely effects photometric parameters such as correlated color temperature (CCT), color rendering (CRI), and luminous efficacy. Thus, arc tubes intended for horizontal operation typically include design features to alleviate these problems.

For example, US Patent 4 001 623 discloses an arc tube having a cylindrical body with press seals and asymmetric end chambers in which the discharge electrodes extend axially but are offset in the same direction from the cylinder axis towards the wall in the plane of the press seal. The arc tube is destined to be used in the position in which the major faces of the press seals are vertically oriented, the electrodes being below the axis. This lowers the arc away from the upper wall to provide a more uniform temperature distribution. In a further embodiment, the upper wall has the shape of a catenary to further improve the temperature profile.

U.S Patent 5,055,740 discloses a similar arc tube in which the greatest length of the discharge space is at the elevation of the electrodes.

U.S. Patent 4,056,751 discloses a alternative design in which the arc tube is arched to match the shape of the discharge arc during lamp operation. This arched shape, however, requires extra glass forming steps to bend the arc tube body, and increases the effective diameter of the arc tube, making it unsuitable for lamps intended for small fixtures.

A disadvantage of all of the above designs is that the major faces of the press seals are vertically-oriented during horizontal operation of the arc tube. It is known from U.S. Patent 4,850,500 that end chambers may typically include irregularities such as corners and crevices, inadvertently formed during pressing, where they meet the press seals of the arc tube. Thus, rather than the smoothly shaped end chamber walls shown in US Patents 4 001 623 ad 5 055 740, in practice these lamps have been found to have crevices "C" at the juncture of the press seals and the end chamber, as shown in Figure 1. When operated horizontally, the cold spot on the arc tube is generally on the lower wall, ad typically behind the electrodes. With vertically oriented press seals, it has been found that the fill constituents tend to condense ad pool in the crevices, reducing the partial pressures of the constituents. The crevices are the source of a larger than desired spread in photometric parameters among a given number of lamps due to the variation in the size and location of the crevices produced during pressing.

In US Patent 4 850 500, the corners are reduced or eliminated by an additional, secondary pressing operation normal to the major faces of the press seal which forms notches, or "dimples", at the juncture of the arc tube body and press seal. However, the secondary pressing operation is an additional manufacturing step, requiring additional press jaws and modified pressing equipment, which adds to lamp cost. Furthermore, this arc tube has a straight cylindrical body with centered axially extending discharge electrodes. This construction suffers from the asymmetric temperature profile of the arc tube wall due to the bowed discharge arc as discussed above.

U.S. Patent 5,016,510 discloses a embodiment of an HID lamp in which the major faces of the press seals are horizontally oriented and the electrodes are aligned on the cylinder axis. The lower wall of the arc tube is locally flattened to move it closer to the discharge arc (Figures 2A and 2B), which requires the extra steps of heating the arc tube along its lower wall ad then pressing it flat. In Figure 2A, the dashed line represents the lower wall of the arc tube prior to flattening. While reducing the temperature difference between the flattened portion of the lower wall and the upper wall, the problem of overheating of the upper wall is not addressed. Additionally, flattening of the lower wall introduces longitudinal zones "A" having a locally irregular curvature. As shown in Figure 2b, the arc tube wall in these zones is further from the discharge arc than the flattened portion and may be the undesired location for condensation and pooling of the fill constituents.

It is the object of the invention to provide a high pressure discharge lamp with an arc tube of improved shape that overcomes the above-mentioned performance and manufacturing disadvantages.

The above object is accomplished in a lamp of the type described in the opening paragraph in that the press seals are offset from the cylinder axis in a same direction normal to their major faces.

The lamp according to the invention is suited to be used in a horizontal position in which the major faces of the press seals extend along a horizontal plane and below the cylinder axis. The lamp has been found to achieve greater uniformity of photometric parameters than prior art lamps having arc tubes with vertically oriented major faces of the press seals. This is believed to be due to the fact that the area where crevices might occur are above the lower wall portion of the end chambers and above the lower wall portion of the generally cylindrical body. This is achieved while maintaining the offset of the electrodes towards the lower wall to minimize the difference in temperature between the upper and lower walls.

As used herein, the terms "upper" and "lower" refer to the portions or walls of the arc tube which are above and below, respectively, the press seals when the arc tube is in a generally horizontal operating position with the major faces of the press seals horizontally below the axis.

According to a favorable embodiment, the press seals are offset from the cylinder axis by the same distance, thereby lying in a common plane. The discharge electrodes extend axially, aligned with each other and with a central plane P normal to the major faces of the press seals and through the cylinder axis. The discharge electrodes are then equally distant from the respective lower wall of the end chambers and the wall of the cylindrical body, providing a favorably symmetric temperature profile across the length of the arc tube.

In another embodiment, the arc tube further includes a starting electrode adjacent one of discharge electrodes. The lead-throughs of the starting and discharge electrodes are laterally offset in the press seal on opposite sides of the cylinder axis, and the discharge electrode is angled laterally towards the central plane P with its tip centered on the plane P. This arrangement is advantageous because it provides ample spacing between the lead-throughs of the staring and the discharge electrodes, and between the lead-throughs and the side edges of the press seal so that seal reliability is maintained.

According to a favorable embodiment of the invention, the cylindrical body of the arc tube is a cylinder having a circular cross-section. This is advantageous because fused silica tubing of circular cross-section is used for arc tubes for vertical operation, obviating the need to stock or produce different tube shapes. Circular tubing is also the cheapest and easiest to handle. Furthermore, extra glass forming steps such as bending the tube are not required as in some prior art lamps. Thus, lamp cost is minimized while achieving greater uniformity in performance among manufactured lamps.

These and other aspects and advantages of the invention will become apparent from the drawings and detailed description which follow.

Figure 1 illustrates an arc tube according to the prior art;
Figure 2A illustrates another arc tube according to the prior art;
Figure 2B shows a cross-section of the arc tube of Figure 2A taken on the line 2B-2B;
Figure 3 illustrates an HID metal halide lamp according to the invention;
Figure 4A is a side view of an arc tube according to the invention;
Figure 4B is a top view of the arc tube of Figure 4A;
Figure 4C is a cross-section of the arc tube of Figure 4a taken on the line 4C-4C;
Figure 5 is a top view of an arc tube according to another embodiment of the invention;
Figures 6A and 6B illustrate the arrangement of the fused silica tube, press jaws, and lead-through according to the preferred method of producing the arc tube;
Figure 6C is a front view of one of the press jaws; and
Figure 7 is a graph illustrating the temperature profile of an arc tube according to Figure 5.

Figure 3 shows a high pressure metal halide discharge lamp having a lamp base 1 connected to an outer envelope 2 in which an arc tube 3 is disposed. Current supply conductors 6, connected to respective contacts on the lamp base 1, extend from the lamp stem 5 into the outer envelope and are electrically connected to respective conductive lead-throughs 7 of the arc tube 3 for supplying electric current thereto and supporting the arc tube within the outer envelope.

Figures 4A, 4B show the arc tube 3 in more detall. The arc tube has a cylindrical body 10 which defines a cylinder axis 11 and is sealed at each end by respective press seals 12 to enclose a discharge space 14. The press seals 12 each have opposing major faces 12a. The discharge space contains a conventional filling comprised of mercury and one or more metal halides such as scandium iodide and sodium iodide, and a rare gas, such as argon. The foliated lead-throughs 7 are conventional and include an outer lead 7a welded to a molybdenum foil 7b. Conventional wire-wound discharge electrodes 15 are disposed in end chambers 16 of reducing cross-section adjacent the press seals 12. The electrode rods

15a are welded to the foils 7b in a conventional manner.

According to the invention, the press seals 12 are offset from the cylinder axis 11 towards the lower wall 10a of the arc tube by a predetermined distance 'z' in a direction normal to the major faces of the press seals and away from the tipped-off tubulation 17. Any crevices which might be formed during pressing are in the press seal at the juncture of the press seal and end chamber and are situated above the lower wall portions 10a, 16a.

In the embodiment shown in Figures 4A-4C, the cylindrical body 10 is a right circular cylinder and the press seals 12 lie in a common plane 13. The discharge electrodes 15 are aligned in said common plane 13 with one another and extend in a central plane P normal to the major faces of the press seals through the cylinder axis 11. The end chambers 16 are asymmetric about the press seal plane 13 (Fig. 4A). The arc tube is symmetric about the central plane P, as illustrated in Figures 4B and 4C. In contrast, the arc tubes of Fig. 1 are symmetric about the press plane. The specific shape of the end chambers shown is discussed below in the description of the pressing method.

During lamp operation in its horizontal position shown in Figures 3 and 4A, the discharge arc arches upwards due to convection currents in the arc tube. Because the press seals and the discharge electrodes are displaced closer to the lower wall portion 10a and further away from the upper wall portion 10b, overheating of the upper wall 10b is avoided and a more uniform temperature profile is achieved than if the discharge electrodes were centered on the arc tube axis. During horizontal lamp operation, the cold spot of the arc tube, which is where the metal halides condense and which controls the partial pressures of the metal halides, is located on the lower wall 10a in contrast to the prior art lamp, in which the cold spot is in the crevices in the seal below the electrodes at an even lower temperature. This is favorable for lamp photometric parameters. Additionally, lamps according to the invention were found to have a smaller lamp-to-lamp variation in photometric parameters because of the absence of crevices in areas where the fill constituents condense. Any crevices which form as the result of the press sealing process lie in the common plane 13 of the press seals, well above the locations of lowest temperature at which the lamp fill constituents condense and pool.

Figure 5 shows a lamp according to another embodiment of the invention which includes a staring electrode 17 at one end of the arc tube. The lead-throughs 7 of the starting electrode 17 and of the discharge electrode 15 are positioned in the press seal laterally offset on opposite sides of axis 11. The electrode rod 15a of the discharge electrode is welded to the foil 7b at an angle such that its tip 15c is laterally positioned below the axis 11 in the common plane through the press seals. The starting electrode is conventionally positioned adjacent the discharge electrode to facilitate lamp starting and may be angled towards the discharge electrode or extend axially. The discharge electrode at the other end of the arc tube without the starting electrode may likewise be offset and angled or it may extend axially on the centerline.

Metal halide lamps with starting electrodes are typically those with a rated power of 150W or greater. Lamps of smaller wattage can typically be started without starting electrodes using a high voltage pulse instead. For manufacturing considerations, lamps without starting electrodes may similarly have one or both discharge electrodes angled in the plane of the press as shown in Figure 5 to facilitate common tooling.

In manufacturing the arc tubes, the press seals are positioned offset from the cylinder axis of the tube a predetermined distance in a direction normal to the plane of the press seals.

Favorably, this is accomplished by forming the press seals offset from the cylindrical axis of the tube according to the following steps. As shown in Figure 6A, a length of circular cylindrical fused silica tube 20 already provided with a tubulation 22 is held by this tubulation in a tubulation holder 40. The discharge electrode, and the starting electrode if included, are held in a chuck 41 and positioned longitudinally with respect to the quartz glass tube and offset from the cylinder axis 11 a predetermined distance "z". The opposing press jaws 30, 31 include mold portions 32, 33 for forming the end chambers. The jaws are arranged and moved so that in their closed position their opposing faces 38, 39 are equidistant from the lead-through 7. After heating the end portion of the tube to its softening temperature in a conventional manner, the press jaws are quickly pressed together, forming a press seal 12 about the lead-through offset from the axis 11 and coplanar with the discharge electrode (Fig. 6B). A pressure of nitrogen is provided through the tubulation 22 to blow the softened glass outwardly against the mold portions 32, 33 in the closed position of the jaws to precisely form the end chambers.

A press seal is then formed at the other end of the tube offset the same distance "z" from the tube axis such that it is coplanar and symmetric with the press seal formed at the first end. The arc tube is then conventionally dosed through the tubulation, which is then tipped off.

The opposing press jaws are asymmetric with respect to each other (Fig. 6B) in cross-sections normal to the plane of the press seal. The mold portion 32 of the bottom press jaw 30 includes a first arc 34 with a radius R1 merging into a bottom surface 35 parallel to the press plane. The mold portion of the top press

jaw 31 includes a second arc 35 with the same radius R1 and a top surface 37 angled with respect to the press plane. The press faces 38, 39 are substantially flat for forming the generally planar press seal about lead-through 7 or may include reliefs for forming detents for frame support straps, etc. As shown in Figure 6C, the mold portion of the press jaw 30 includes angled side edges 38a which merge into a rounded edge 38b at the face 38. The rounded edge 38b has the same radius R1. The press jaw 31 includes identical edges at its face 39, so that the resulting end chamber has a hemispherical portion with radius R1 behind the electrode. The jaws may be readily fabricated accorded to well known machining techniques.

The wall thickness of the end chambers was found to be surprisingly uniform despite the offset of the press seal from the tube axis. Thinning of the upper wall 16a as compared to the lower wall 16b, which might be expected due to the different distances over which the opposing sides of the softened end portions are displaced by the press jaws, substantially did not occur. This is believed to be due to the blow molding of the heat softened end portion into the mold chambers along with an inherent gathering action of the softened quartz glass. Accordingly, the inner surface of the end chambers is defined by the shape of the press jaw mold portions 32, 33.

In order to establish the operability of lamps according to the invention, 400 W metal halide lamps were made by the above-described method with an offset press seal as shown in Figure 5. These lamps were compared with "Prior Art" lamps having a arc tube with vertical press seals and asymmetric end chambers as shown in Figure 1. The quartz glass tubing of the lamps according to the invention had a circular cross-section with an inside diameter of 14 mm, the distance between the electrode tips was 43 mm, the insertion depth of the electrode tips from the rear of the end chambers was 7 mm, and the offset distance "z" from the axis of the cylinder was 4 mm. The radius R1 was 4.7 mm. The arc tubes had a filling of argon at a cold fill pressure of 35 Torr and were dosed with 17 mg Hg, 3.9 mg HgI_2, 16.1 mg NaI and 1 mg Sc. The prior art lamps with asymmetric press seals had a circular cross-section with an inside diameter of 14 mm, the distance between the electrode tips was 43 mm, the insertion depth of the electrode tips from the rear of the end chambers was 7 mm, and the offset distance 'z' from the axis of the cylinder was 2.5 mm. The arc tubes had the same filling.

The photometric quantities at 1000 hours are shown in Table 1 for both groups of lamps, each group having 6 lamps. The standard deviation for each measurement is shown in parenthesis.

TABLE 1

	Invention	Prior Art
Lamp Voltage (V)	146.5 (6.8)	137.5 (11.7)
Light output (1m)	32070 (1130)	30894 (2180)
Efficacy (1m/W)	80.2 (2.79)	77.3 (5.5)
CCT (K)	4721 (146)	5091 (469)
CRI	73.2 (1.5)	73.4 (2.6)

It can be seen that the efficacy is higher and the standard deviation of the parameters mentioned is significantly less for the lamps according to the invention than for the prior art lamps. The standard deviations for the luminous efficacy, correlated color temperature (CCT), and color rendering index (CRI) were 49%, 68% and 42% lower, respectively, for the lamps according to the invention.

Figure 7 shows the temperature profile across the length of the arc tube for the lamp according to the invention. The maximum temperature difference between the upper and lower walls of the arc tube was about 75 °C and the maximum temperature for the upper wall was approximately 850 °C. The low temperature difference contributes favorably to lamp performance while the maximum temperature of about 850 °C does not inhibit lamp life.

It is readily apparent that other arc tube cross-sections, such as oval, will benefit from the offset press seals according to the invention.

Claims

1. A high pressure discharge lamp having an arc tube (3) for operation in a generally horizontal position, said arc tube having a generally cylindrical body (10) defining a cylinder axis (11), end chambers (16) of reducing cross-section, an arc discharge sustaining filling, a pair of opposing discharge electrodes

(15) arranged substantially in said end chambers, and press seals (12) each having opposing major faces (12a), sealing each end of said arc tube in a gas-tight manner, characterized in that

said press seals (12) are offset from said cylinder axis (11) in a same direction normal to their major faces (12a).

2. A high pressure discharge lamp according to Claim 1, wherein said press seals (12) lie in a common plane.

3. A high pressure discharge lamp according to Claim 1 or 2, wherein said arc tube is symmetrical about a central plane (P) through said cylinder axis (11) and normal to the major faces (12a) of the press seals (12).

4. A high pressure discharge lamp according to Claim 3, wherein said cylindrical body (10) is a right circular cylinder.

5. A high pressure discharge lamp according to Claim 3 or 4, wherein said discharge electrodes (15) are aligned with each other in said central plane and extend in said common press seal plane.

6. A high pressure discharge lamp according to Claim 3 or 4, wherein said discharge electrode (15) terminates at a tip thereof and is angled in the plane of said press seal such that said electrode tip is positioned on said central plane (P) and said lead-through extends in said press seal (12) laterally offset from said central plane.

7. A high pressure discharge lamp according to Claim 6, further comprising a starting electrode (17) adjacent said angled discharge electrode (15) and connected to an additional lead-through, said lead-through of said starting electrode (17) being laterally offset within said press seal on the opposite side of said central plane from said discharge electrode lead-through.

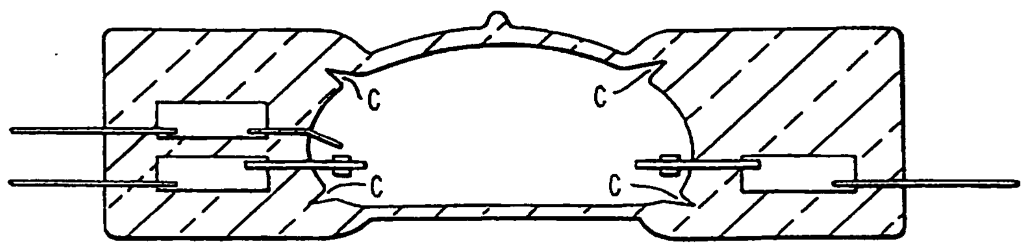


FIG.1

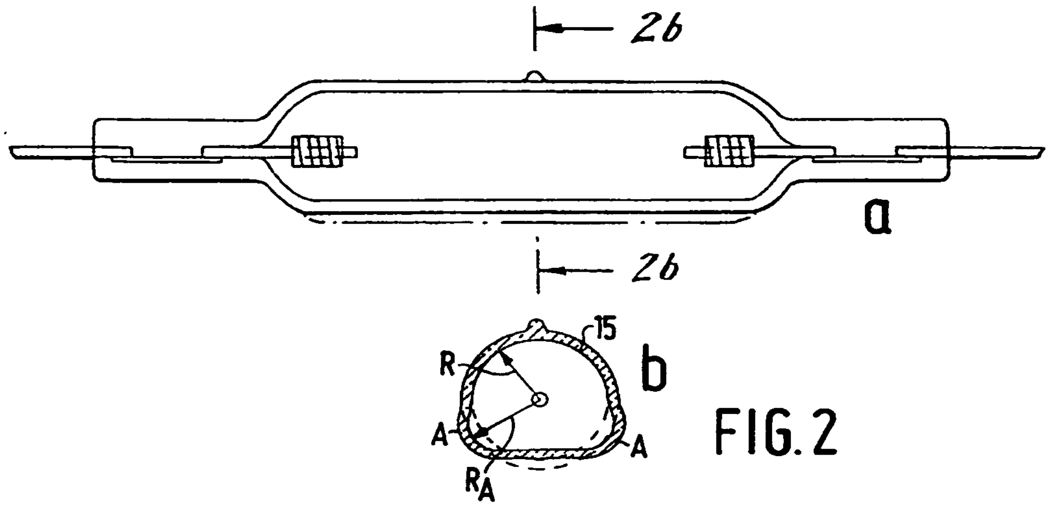


FIG.2

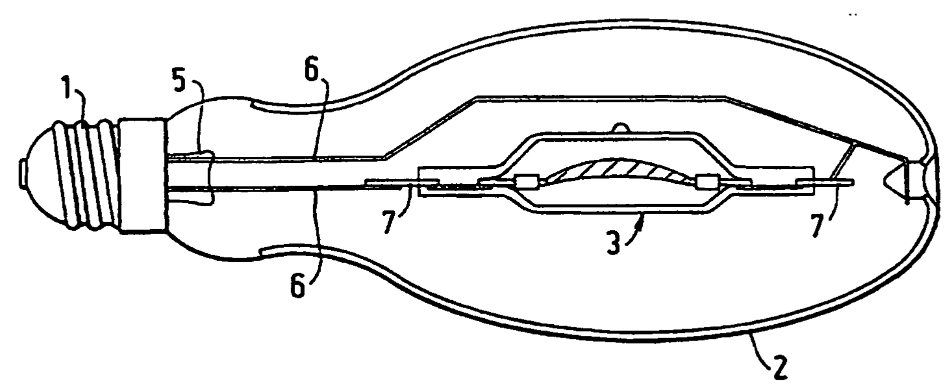
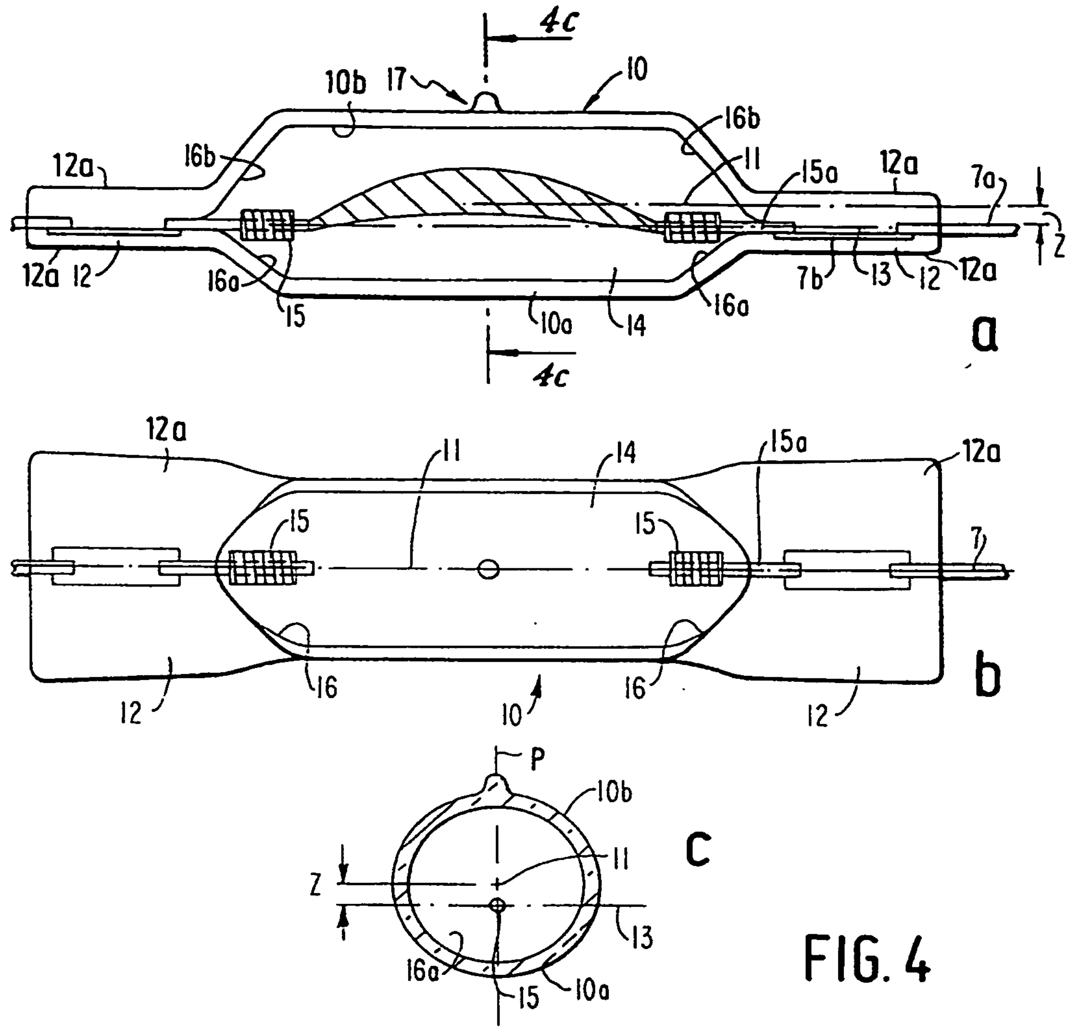


FIG.3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10b
10
16b
12a
11
15a
7a
Z
12
16a
15
10a
14
7b
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b
c
P
16
7

FIG. 4

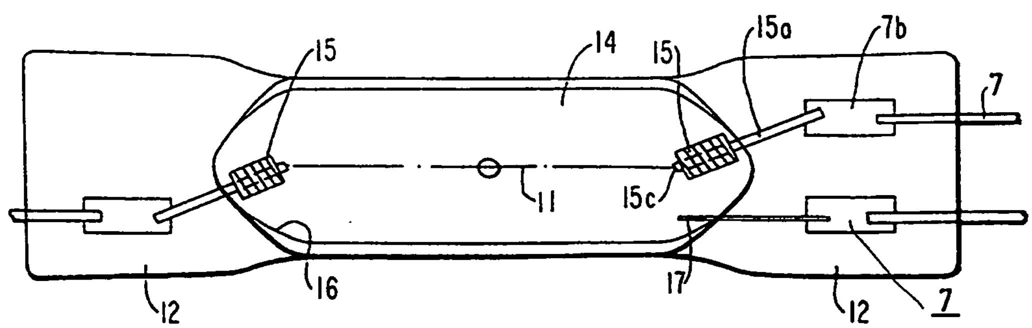

15
14
15a
7b
7
11
15c
12
16
17

FIG.5

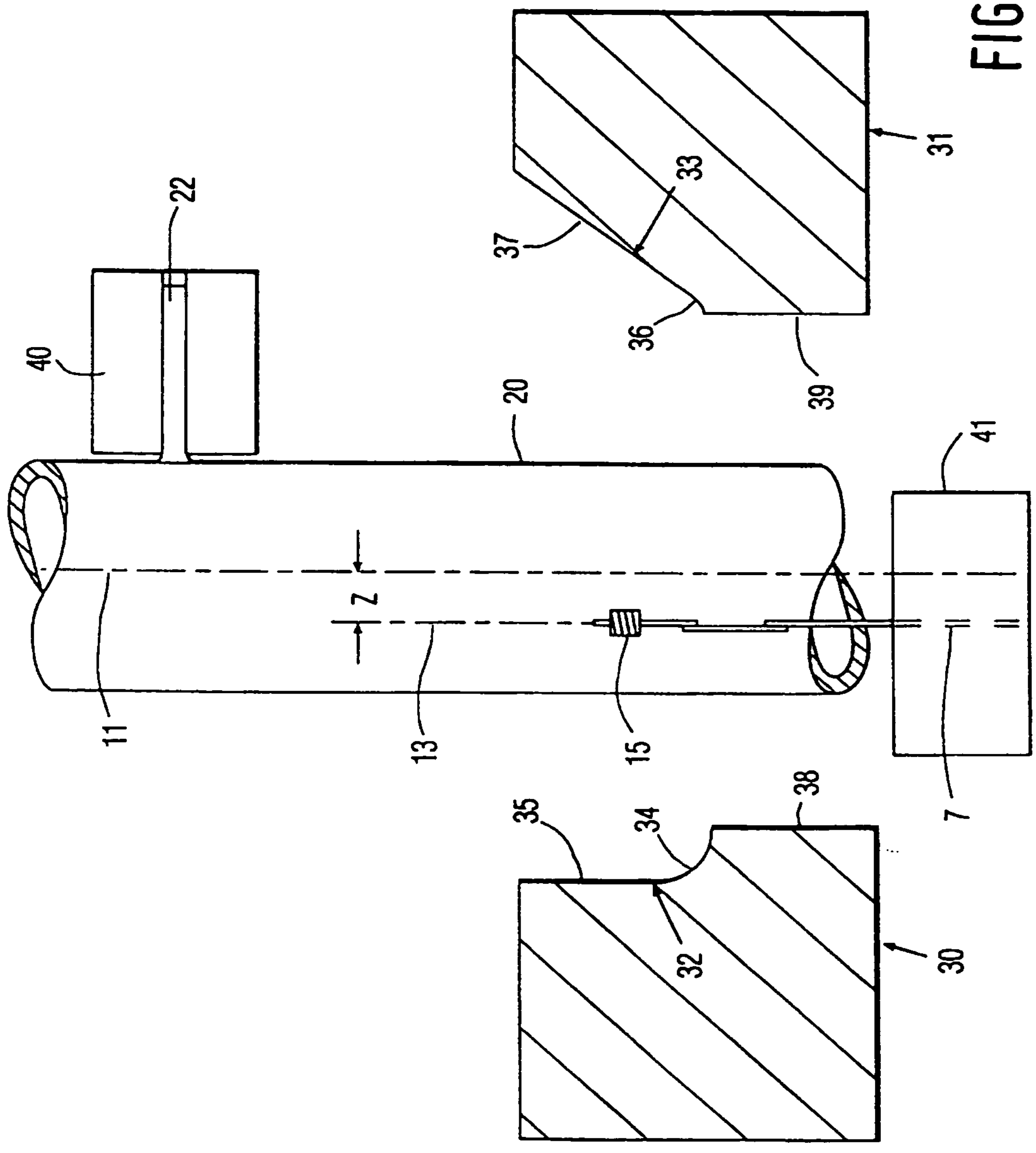
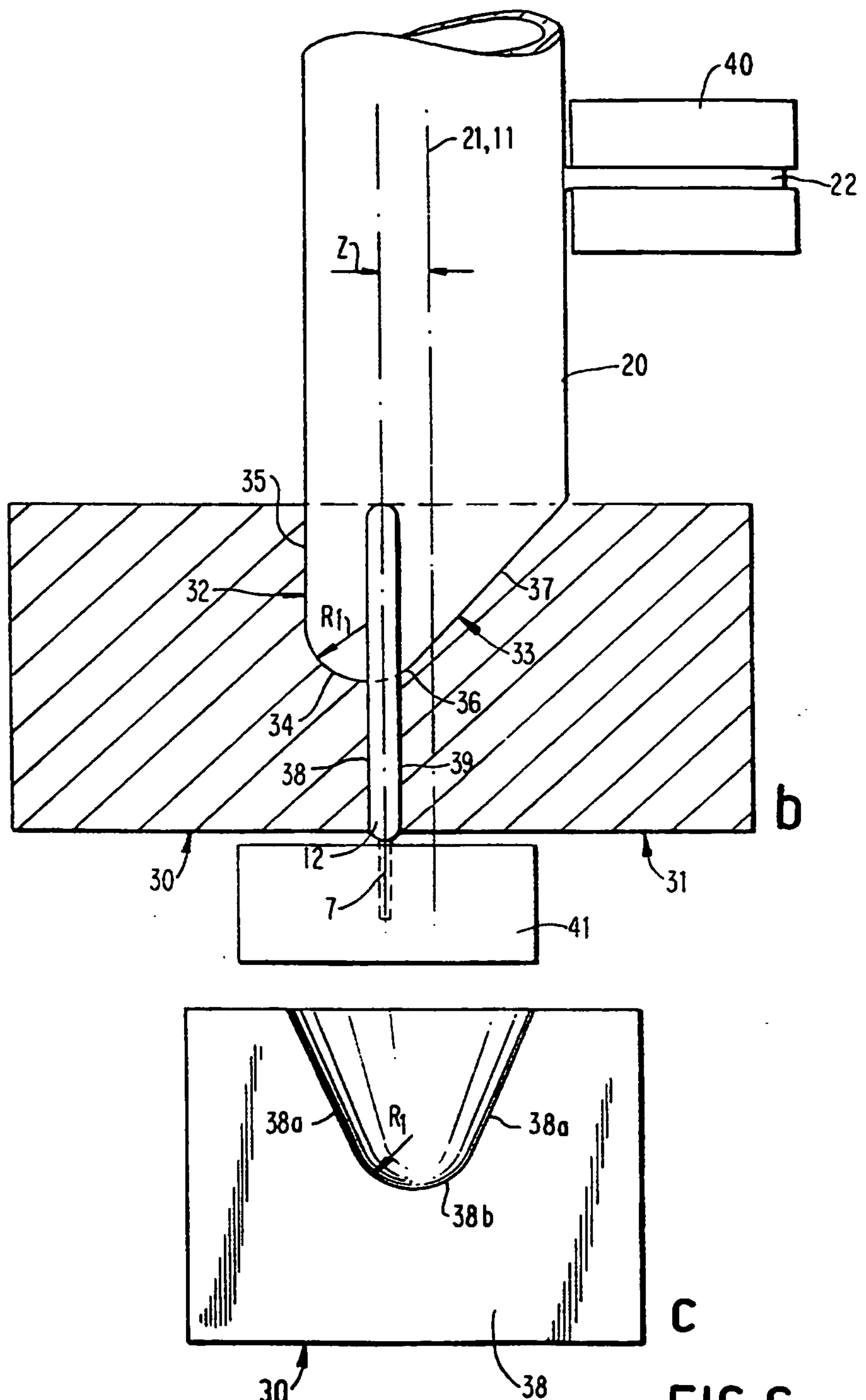


FIG.6a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21,11
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Z
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35
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R1
37
33
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36
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30
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7
41
38a
R1
38a
38b
30
38

b

c

FIG.6

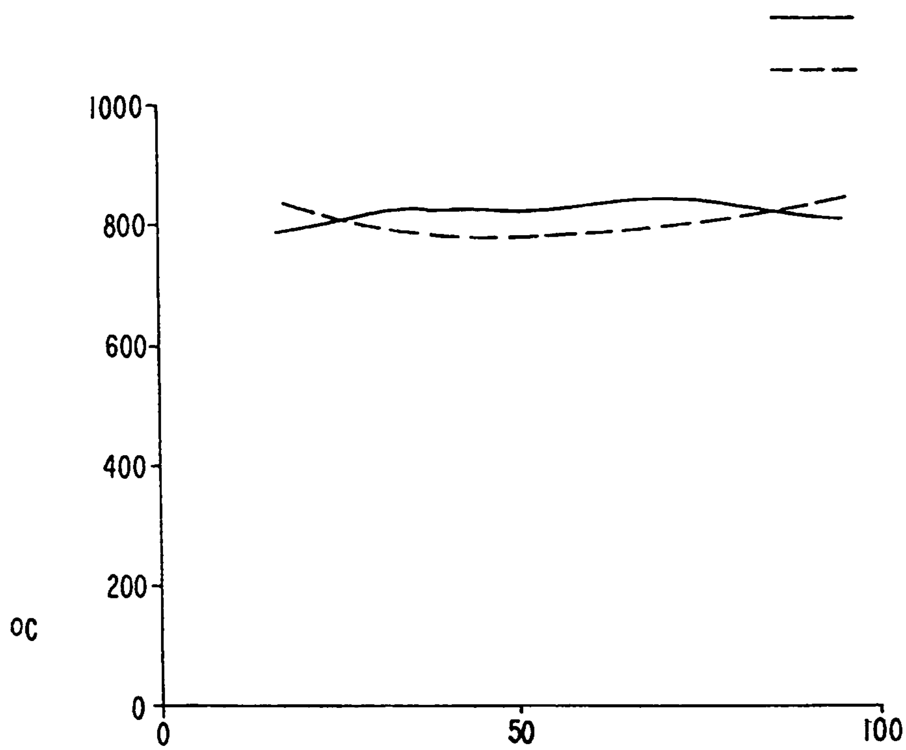

FIG.7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 20 2045

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
D,X	US-A-5 055 740 (SULES.J) 8 October 1991 * column 1, line 1 - line 25 * * column 3, line 15 - line 35 * * column 4, line 7 - line 13; figures 1-4 * ---	1,2	H01J61/33 H01J61/82
A	EP-A-0 206 598 (TOSHIBA) 30 December 1986 * page 4, line 1 - line 10 * * page 4, line 17 - line 28; figure 1 * -----	1,3,6,7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			H01J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 October 1993	ROWLES, K

CATEGORY OF CITED DOCUMENTS

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